REMARKS

The Applicants respectfully request the Examiner to reconsider the present Patent Application in light of the amendments and arguments presented in this First Amendment.

I. Section 112 Rejections

On Page 2, Section 1 of the Office Action, the Examiner rejected Claims 1, 13, 19 and 21 as indefinite because these Claims use the terms "energy source" and "signal" together.

As an example, a pertinent portion of text from Claim 1 follows:

> "providing an energy source (73); said **energy source** (73) disposed on a subject (12) at a location to be tracked; said subject (12) moving from position-to-position within a volume of space (16);
>
> emitting a **signal** (40) from said energy source (73);"

The Specification of the Present Application provides the following support for these two Claim elements:

> "An objective of the present invention is to develop a precision position measurement system that uses radio frequency (RF) phase interferometry. **Energy sources, which are transmitting antennas disposed on a subject,** are continuously located by receiving apparatus to a resolution of one millimeter (mm)."

The Applicants have amended Claims 1, 13 and 19 to replace the term "energy source" with "transmitter". The Applicants believe that this amendment should overcome the Section 112 rejection.

On Page 2, Section 1 of the Office Action, the Examiner rejected Claims 21 and 22 as being indefinite under Section 112. The Applicants have canceled these two Claims, requesting that they be canceled without prejudice, to preserve the Applicants' right to pursue these Claims in a subsequent CIP Application.

On Page 2, Section 1 of the Office Action, the Examiner rejected Claims 30 and 31 as being indefinite under Section 112. The Applicants have canceled these two Claims, requesting that they be canceled without prejudice, to preserve the Applicants' right to pursue these Claims in a subsequent CIP Application.

On Page 2, Section 1 of the Office Action, the Examiner rejected Dependent Claims in the Present Application because they were determined to be indefinite under Section 112. The Applicants believe they have overcome these rejections by making the amendments to Independent Claims 1, 13 and 19.

II. Section 102(b) Rejections.

On Pages 3 and 4 of the Office Action, in Sections 2 and 3, the Examiner rejected Claims 1, 2, 13, 14, 15, 16, 18, 22-24 and 26-29. The Applicants respectfully traverse this rejection based on Section 102(b).

The Applicants contend that a rejection under Section102(b) is unfounded based on the disclosure of the cited references. None of the cited references disclose a method which matches the limitations recited in Claim 1:

As an example, in Claim 1, the Applicants recite, in part:

"measuring a phase difference ($\Delta\phi 2$) of said signal (40) being received at each said independent pair of said plurality of receiving antennas (76, 78) when said ~~energy source~~ <u>transmitter</u> (73) is at a second position (74); and

estimating a change in said physical position of said ~~energy source~~ <u>transmitter</u> (73) by comparing measured phase differences ($\Delta\phi 1$, $\Delta\phi 2$) of received said signal (40) at each said independent pair of said plurality of receiving antennas (76, 78)."

None of the references cited by the Patent Office suggests relating the phase difference of a simple continuous wave signal to the range difference from the transmitter to two widely separated receiving antennas. This is apparent because none of them discusses how to deal the ambiguities that the present invention resolve. The cited references are essentially time-of-arrival or time and angle-of-arrival systems, and focus on a single snapshot location estimate. None involves using temporal processing to improve the location estimate and/or to help resolve locational ambiguities.

The Applicants contend that the Original Claims are patentable over the cited references, but, in the spirit of seeking a speedy allowance of the Present Application with minimal additional prosecution, have amended Claim 1, as well as the other two Independent Claims 13 and 19, to limit their Invention to methods and apparatus for:

> **"capturing the position and movement of a subject living body."**

The Patent Office cited nine documents in the First Office Action:

Hammack 263
Hammack 096
Hammack 911
Hammack 590
Yokev 330
Otto 584
Sypniewski 076
Parl 598
Sullivan 131

Some of these documents teach a system for tracking an "unfriendly" or "enemy" object which does not carry a transmitter that emits a radio signal which is used to determine the location of the objection. The Applicants' Invention utilizes transmitters placed on a "friendly" object whose motion must be tracked.

Some of these documents mention phase information, but none of the documents cited by the Patent Office teach, disclose or suggest the use the method or apparatus recited in the Applicants' Claims.

Hammack 263 describes a method for "detecting and tracking reflective objects." Col. 1, Lines 11-12. "At each receiving site the time between the arrival of a pulse from one of the transmitters and a pulse from the other transmitter is measured." Col. 2, Lines 53-56. Hammack 263 does not teach or suggest any type of differential phase measurement as recited in the Applicants' Claims.

Hammack 096 discloses a reflecting system for detecting non-cooperative targets, such as a "strange and hostile space vehicle." Col. 3, Line 14 and Col. 12, Lines 62. "Each of the stations 1-6 is identical to the others and consists of a transmitter to illuminate the target and a receiver tuned so as to receive signals reflected to it from the target. Each station then makes a completely independent measurement of radial velocity with reference to the missile or target simultaneously." Col. 7, Lines 14-15. Unlike the Applicants' Invention, the objects which must be tracked are unfriendly, and do not carry transmitters that emit a signal that is received and processed. Furthermore, Hammack 096 does not teach or suggest any type of differential phase measurement as recited in the Applicants' Claims.

Like Hammack 096, Hammack 911 discloses a method for tracking objects which do not carry transmitters. Hammack discloses "a simple system designed to track a single aircraft of space vehicle without relying on equipment placed aborad the vehicle." Col. 8, Lines 1-3. This third Hammack Patent describes a system that uses fixed stations to emit signals to track a moving object. This Patent describes a multistatic system for tracking moving objects (Col. 59, Lines 14-15) to track an aircraft or space vehicle. Col. 8, Lines1-3. The actual detecting equipment consists of three fixed transmitter-receiver stations designated as stations 1, 2 and 3 in FIG. 1. Col. 8, Lines 14-16. Like both Hammack 263 and 096, Hammack 911 does not teach or suggest any type of differential phase measurement as recited in the Applicants' Claims.

Hammack 590 discloses neither a transmitter aboard the object which must be tracked, nor any form of differential phase measurement. This fourth Hammack Patent discloses additional methods and apparatus for using stationary transmitters to illuminate moving objects with signals that enable the moving objects to be

tracked. This Patent specifically pertains to air traffic control and collision avoidance. Col. 2, Line 2. Fig. 1 shows a system of six Doppler stations designated 1 through 6 for performing six simultaneous partial measurements of the motion of a vehicle. Col. 5, Lines 45-47.

Sypniewski 076 explains how to measure the differences between a propagation time of the carrier from transmitter to each stationary antenna element of the array receiver. Col. 2, Line 67. The number of antenna elements employed to make this measurement must be larger then the number of dimensions by at least one. Col. 3, Line 13. Sypniewski does not teach any form of differential phase measurement as claimed by the Applicants.

Otto 584 teaches the method of determining the time of arrival and the angle of arrival of a signal from a target unit in a geolocation system. Abstract & Col. 2, Line 27. Otto utilizes plural fixed receiving sites, and uses the angle of arrival of the signal at the receiving sites to determine the geolocation of the target unit. Col. 2, Lines 38-42. Although Otto compares the instantaneous phase of the arriving signal at each of the plural antennas, this reference to phase information is not the same as the method recited in the present Application. Col. 3, Lines 42-47.

Otto's system is based on each receiving antenna determining the time-of-arrival and angle-of-arrival of the transmitted signal. See Abstract. Otto requires rotating antennas (Page 3, Line 4) or multiple antennas (Page 3, Lines 41-44) at each receiving station to determine angle-of-arrival. Otto does not mention the phase of the transmitted signal.

Parl 598 discloses a system in which base stations report amplitude, phase and time data related to the locating signal to a control station. Abstract. A plurality of base stations receive the locating signal from the portable unit. Col. 1, Line 60. Although Parl mentions the reporting of phase data in his Abstract, he does not teach, disclose or suggest the method or apparatus recited in the present Application.

Parl 598 uses signal phase and amplitude to determine range and angle-of-arrival. Parl's processing method requires at least three antennas at each receiving location to form three-dimensional estimates Col. 2, Lines 22-27. Parl requires each receiving site to have at least two antennas, each receiving at least two frequencies. Page 15, Lines 56-60.

Sullivan 131 describes an antenna array at each base station for receiving an emitter signal. Abstract, Line 15. Sullivan requires at least three mutually dispersed base station sites. Col. 1, Line 2. While Sullivan does mention phase information, he does not teach or disclose the method and apparatus claimed by the Applicants.

Sullivan 131 uses an antenna array and a beam former at each receiving site. Abstract. Sullivan requires the transmitted signal to have a cyclostationary modulation Page 4, Lines 50-57 instead of a simple continuous wave signal. Sullivan essentially describes a time-of-arrival system. On Page 6, Lines 44-47, one embodiment has each receiving station establish the absolute time for the receipt of the signal. On Page 6, Lines 57-65, another embodiment has the system identify distinct signal features to establish and absolute time of receipt of this signal feature at each receiving station. Once having established the absolute time at which some signal feature was received at each of the receiving antenna, Sullivan uses the same differential range calculation used in the GPS system to estimate the location of the transmitter.

Yokev 330 explains how a transmitter simultaneously transmits two radio frequency carriers having different frequencies such that a phase difference is observed between the two carriers at a distance from the transmitter. The phase difference is proportional to the range from the transmitter that the carrier signals are observed. Abstract, Lines 4-9. Yokev uses a modified time-of-arrival technique. Col. 2, Lines 28-29. While Yokev refers to phase differences, he does not teach or suggest the method or apparatus recited in the Applicants' Claims.

Yokev 330 requires a complex frequency hopped transmitter. The disclosure in Col. 2, Lines 37-47 requires 53 frequency hops per transmission to calculate an unambiguous range at each basestation. Yokev also requires complex processing at each receiving station. The disclosure in Col. 2, Lines 60-64 requires highly accurate rubidium clocks at each basestation to determine the exact time-of-arrival of each frequency hop. Yokev does not use the phase differences of the frequency-hopped signal to infer range, since it uses the exact times of the frequency hops to create time-difference-of-arrival measurements. In Col. 2, Lines 66-67, Yokev states that the central station compares the time-of-arrivals of the frequency hops with the knowledge that each basestation has made its calculations on the same time standard. This emphasis is also clear from the many parallels drawn in Yokev to the GPS system, which is also a differential time-of-arrival

system. The complexity of this system can also be inferred from the illustrations of the preferred embodiment which envision the transmitter's being carried in a car, as opposed to the present invention, which includes many very minimal transmitters fastened at various places on a person's body.

Unlike the Applicants' Invention, the cited references generally disclose methods and apparatus for determining location of equipment like ground vehicles, aircraft, missiles and submarines. The Applicants believe that this new added limitation causes Amended Independent Claims 1, 13 and 19 to be completely overcome the Section 102(b) rejection, since none of the cited references disclose capturing the position and movement of a subject living body.

III. Section 103 Rejections

In Sections 4 and 5 of the Office Action, on Page 4, the Examiner rejected Claims 17 and 25 as being obvious under Section 103.

The Applicants respectfully contend that the claims on which Dependent Claims 17 and 25 depend are patentable over the references cited in the Office Action, so that the additional limitation of using the 2.5GHz frequency band only provides an additional distinguishing limitation.

As the Examiner admits in the Office Action, none of the cited references specify using the 2.5 GHz. The Examiner states that "any desired RF frequency could be used." This is not the case. If the AM band were used, the present invention would not only be overwhelmed by interference from commercial AM stations, but the wavelength would be inappropriately long compared to the dimensions of the body whose motion is being captured within a relatively small volume of space. The use of the 2.5GHz frequency band is a carefully designed and determined optimal use, selected to enable a beneficial implementation of the present invention based on a careful consideration of the physics of the problem at hand. For this reason, the Applicants respectfully traverse the Section 103 rejection, and contend that any rejection based on an arbitrary determination by the Patent Office that "any desired RF frequency could be used" to implement the Present Invention is unfounded in the Patent Laws.

IV. Section 101 Rejections.

In Section 6 of the Office Action, on Pages 4 and 5, the Examiner rejected Claims 30 and 31 as being unpatentable under Section 101. The Applicants have requested that Claims 30 and 31 be canceled, without prejudice, to preserve the Applicants' rights to pursue these Claims in a subsequent Patent Application.

COMPLETE LISTING OF ALL CLAIMS IN THE PRESENT APPLICATION

1. (Currently amended.) A method ~~of motion capture~~ for capturing the position and movement of a subject living body comprising the steps of:

providing ~~an energy source~~ a transmitter (73); said ~~energy source~~ transmitter (73) disposed on a subject (12) at a location to be tracked; said subject (12) moving from position-to-position within a volume of space (16);

emitting a signal (40) from said ~~energy source~~ transmitter (73);

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providing a plurality of widely-spaced receiving antennas (76, 78) disposed at edges of said volume of space (16);

measuring a phase difference ($\Delta\phi 1$) of said signal (40) being received at each independent pair of said plurality of receiving antennas (76, 78) when said ~~energy source~~ transmitter (73) is at a first position (72);

changing a physical position of said ~~energy source~~ transmitter (73) from a first position (72) to a second position (74);

measuring a phase difference ($\Delta\phi 2$) of said signal (40) being received at each said independent pair of said plurality of receiving antennas (76, 78) when said ~~energy source~~ transmitter (73) is at a second position (74); and

estimating a change in said physical position of said ~~energy source~~ transmitter (73) by comparing measured phase differences ($\Delta\phi 1$, $\Delta\phi 2$) of received said signal (40) at each said independent pair of said plurality of receiving antennas (76, 78).

2. (Currently amended.) The method as claimed in Claim 1, in which the step of providing ~~an energy source~~ (73) disposed on a subject (12) includes the step of providing a low-power radio frequency transmitter (30) coupled to a marker antenna (14) on said subject (12).

3. (Currently amended.) The method as claimed in Claim 1, in which the step of estimating a change in said physical position (72, 74) of said ~~energy source~~ (73) by comparing measured phase differences ($\Delta\phi$) of received said signal (40) at each one of said plurality of receiving antennas (76, 78) further includes the steps of:

measuring a signal phase (ϕ) at each one said widely spaced plurality of receiving antennas (76, 78) when said subject living body (12) is at a first position;

moving said ~~energy source~~ (73) with said subject living body (12) from said first position (72) a distance (82) to said second position (74);

measuring a change of said received signal phase ($\Delta\phi$) at each of said widely spaced plurality of receiving antennas (76, 78) when said energy source is at said second position (74);

estimating the direction of motion and the distance ~~moved 82~~ 82 moved by comparing said measured change of received signal phase ($\Delta\phi$) at said widely-spaced plurality of receiving antennas (76, 78); said received signal phase (ϕ) being dependent only on a signal wave length (λ) and said distance and direction moved (82) by said ~~energy source~~ (73); and

continuing said movement (82) and repeating said signal phase measurements, thereby tracking the direction and motion of said ~~energy source~~ (73) without use of an absolute phase reference.

4. (Currently amended.) The method as claimed in Claim 1, in which the step of estimating a change in said physical position (72, 74) of said ~~energy source~~ (73) by comparing measured phase differences ($\Delta\phi$) of received said signal (40) at each one of said plurality of receiving antennas (76, 78) further includes the steps of:

measuring a signal phase difference ($\Delta\phi$) of received said signal (40) at each one of said widely spaced plurality of receiving antennas (76, 78);

evaluating all allowable values of a difference of pairs (Δn) of integer values (n1, n2) which give the same said measured value of said signal phase difference ($\Delta\phi$);

selecting a set of said values of a difference of pairs (Δn) of integer values (n1, n2) for which surfaces of all hyperbolas of revolution which are defined by said difference of pairs (Δn) of integer values (n1, n2) intersect at a same point; and

said same point of intersection being said physical position (74) of said ~~energy source~~ (73) at the time of said signal phase difference ($\Delta\phi$) measurement.

5. (Currently amended.) The method as claimed in Claim 2, in which the step of emitting a signal (40) from said ~~energy source~~ (73) includes emitting a microwave signal (40) from said marker antenna (14).

6. (Original.) The method as claimed in Claim 4, in which said microwave signal is at a frequency of approximately 2.4 GHz.

7. (Original.) The method as claimed in Claim 5, in which said plurality of receiving antennas (76, 78) includes at least four receiving antennas.

8. (Original.) The method as claimed in Claim 6, adapted to mapping of human muscle, joint and bone interactions for performing clinical gait analysis of persons having neuromuscular, musculoskeletal, or neurological impairments.

9. (Original.) The method as claimed in Claim 6, adapted to mapping and analysis of human body motion for improving performance in sports.

10. (Original.) The method as claimed in Claim 6, adapted to mapping human body motion for evaluation of human interaction with military equipment.

11. (Original.) The method as claimed in Claim 6, adapted to tracking body motion of humans and animals for implementing realistic animation in film and television entertainment.

12. (Original.) The method as claimed in Claim 6, adapted to tracking body motion of humans and animals for implementing realistic animation in computer games and presentations.

13. (Currently amended.) An apparatus for capturing the position and movement of a subject living body comprising:

a transmitter ~~an energy source~~ (73); said ~~energy source~~ (73) disposed on a subject (12) at a location to be tracked; said subject (12) moving from position-to-position within a volume of space (16); said transmitter ~~energy source~~ (73) emitting a signal (40);

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a plurality of widely-spaced receiving antennas (76, 78), each one of said plurality of receiving antennas (76, 78) being disposed at edges of said volume of space (16);

a phase difference ($\Delta\phi 1$), of said emitted signal (40) being measured at each independent pair of said plurality of receiving antennas (76, 78) when said transmitter ~~energy source~~ (73) is at a first position (72);

a phase difference ($\Delta\phi 2$), of said emitted signal (40) being measured at said independent pair of said plurality of receiving antennas (76, 78) after moving said transmitter ~~energy source~~ (73) from a first position (72) to a second position (74); and

a change (82) in said physical position (72, 74) of said transmitter ~~energy source~~ (73) being determined by comparing a change in said measured phase difference ($\Delta\phi 2$-$\Delta\phi 1$) of received said signal (40) at each said independent pair of said plurality of receiving antennas (76, 78).

14. (Currently amended.) The apparatus as claimed in Claim 13, in which said transmitter ~~energy source~~ (73) disposed on a subject (12) includes a low-power radio frequency transmitter (30) coupled to a marker antenna (14).

15. (Currently amended.) The apparatus as claimed in Claim 13, in which:

the direction of motion and the distance moved (82) by said transmitter ~~energy source~~ (73) being dependent only on a signal wave length (λ) and a change of relative phase of the received, propagated signal (40); and

said measurements being repeated as said movement (82) continues, thereby tracking the direction and motion of said transmitter ~~energy source~~ (73) without use of an absolute phase reference.

16. (Currently amended.) The apparatus as claimed in Claim 14, in which said emitted signal (40) from said transmitter ~~energy source~~ (73) includes a microwave signal (40) from said marker antenna (14).

17. (Original.) The apparatus as claimed in Claim 16, in which said microwave signal is at a frequency of approximately 2.5 GHz.

18. (Original.) The apparatus as claimed in Claim 16, in which said plurality of receiving antennas includes at least four receiving antennas.

19. (Currently amended.) A method for capturing the position and movement of a subject living body ~~of motion capture~~ comprising the steps of:

providing a transmitter ~~an energy source~~ (102); disposing said transmitter ~~energy source~~ (102) on a subject (12) at a location to be tracked; said subject (12) moving from position-to-position within a volume of space (16);

emitting a signal (40) having a wavelength (λ) from said transmitter ~~energy source~~ (102);

providing a plurality of widely-spaced receiving antennas (108, 110) disposed at edges of said volume of space (16);

representing a length (d) of each signal path (104, 106) from said transmitter ~~energy source~~ (102) to each one of said plurality of widely-spaced receiving antennas (108, 110) as an integer number (n) of said signal wavelengths (λ) plus a fractional signal wavelength (δ); a difference in signal path length (Δd) to each one of any pair of said plurality of widely-spaced receiving antennas (108, 110) being characterized by a difference of said integer numbers (n1-n2) multiplied by said signal wavelength (λ) plus a difference in said fractional signal wavelengths (δ1-δ2);

assuming a plurality of values of integer number difference (Δn), a first said integer number difference (Δn1) being characterized as a first integer value (n1) less a second integer value (n2), a second said integer number difference (Δn2) being characterized as a third integer value (n3) less a fourth integer value (n4) and so on, for each value of integer number difference (Δn) possible within said volume of space (16);

measuring a phase difference ($\Delta\phi$) between each said signal (40) received from said transmitter ~~energy source~~ (102) at each said pair of said plurality of receiving antennas (108, 110); each one of said plurality of values of integer number difference (Δn) and each said measured phase difference ($\Delta\phi$) defining a surface of locations (112) upon which said transmitter ~~energy source~~ (102) may be located;

selecting one of said plurality of values of integer difference (Δn) for each pair of said plurality of receiving antennas (108, 110) and calculating a potential ~~energy source~~ location (103) having a smallest mean square distance from all of the surfaces of location (112) defined by said selected values of integer difference (Δn) and said measured phase differences ($\Delta\phi$);

iterating said calculations of said potential energy source location using all of said assumed plurality of values of integer difference (Δn) possible within said volume of space (16) and finding each said ~~energy source~~ position (103) until a final absolute ~~energy source~~ position (103) is found at which a smallest said mean square distance from corresponding said surfaces of location (112) exists.

20. (Original.) The method as claimed in Claim 19, in which the step of providing a plurality of widely-spaced receiving antennas (108, 110) disposed at edges of said volume of space (16), includes providing at least four widely-spaced receiving antennas.

Claim 21 (Canceled.)

Claim 22 (Canceled.)

23. (Currently amended.) The apparatus as claimed in Claim ~~22~~ <u>19</u>, in which said transmitting means (73) includes a low-power, radio frequency transmitter (30) coupled to a marker antenna (14).

24. (Currently amended.) The apparatus as claimed in Claim 23, in which said emitted signal (40) from said <u>transmitter</u> ~~energy source~~ (73) includes a microwave signal (40) emitted from said marker antenna (14).

25. (Original.) The apparatus as claimed in Claim 24, in which said microwave signal is at a frequency of approximately 2.5 GHz.

A/ cancel.

26. (Original.) The apparatus as claimed in Claim 24, adapted to mapping of human muscle, joint and bone interactions for performing clinical gait analysis of persons having neuromuscular, musculoskeletal, or neurological impairments.

27. (Original.) The apparatus as claimed in Claim 24, adapted to mapping and analysis of human body motion for improving performance in sports.

28. (Original.) The apparatus as claimed in Claim 24, adapted to mapping human body motion for evaluation of human interaction with military equipment.

29. (Original.) The apparatus as claimed in Claim 24, adapted to tracking body motion of humans and animals for implementing realistic animation in film and television entertainment.

Claim 30. (Canceled.)

Claim 31. (Canceled.)

CONCLUSION

The Applicants respectfully submit that all the pending Claims, as amended, are patentable over the references cited in the Office Action, and that all the rejections contained in the First Office Action have been overcome.

The Applicants believe that no fee is required to enter this First Amendment, aside from the fee for the Petition for a Three Month Extension of Time, which accompanies this First Amendment.

The Applicants believe that all the Claims pending in the Present Application are now allowable, and request the Examiner to pass this Application to issue.

Respectfully submitted,

30 Sept 2003.

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Transmitted to the Patent Office by facsimile
on 30 September 2003.

4. (Currently amended.) The method as claimed in Claim 1, in which the step of estimating a change in said physical position (72, 74) of said ~~energy source~~ (73) by comparing measured phase differences ($\Delta\phi$) of received said signal (40) at each one of said plurality of receiving antennas (76, 78) further includes the steps of:

measuring a signal phase difference ($\Delta\phi$) of received said signal (40) at each one of said widely spaced plurality of receiving antennas (76, 78);

evaluating all allowable values of a difference of pairs (Δn) of integer values (n1, n2) which give the same said measured value of said signal phase difference ($\Delta\phi$);

selecting a set of said values of a difference of pairs (Δn) of integer values (n1, n2) for which surfaces of all hyperbolas of revolution which are defined by said difference of pairs (Δn) of integer values (n1, n2) intersect at a same point; and

said same point of intersection being said physical position (74) of said ~~energy source~~ (73) at the time of said signal phase difference ($\Delta\phi$) measurement.

5. (Currently amended.) The method as claimed in Claim 2, in which the step of emitting a signal (40) from said ~~energy source~~ (73) includes emitting a microwave signal (40) from said marker antenna (14).

6. (Original.) The method as claimed in Claim 4, in which said microwave signal is at a frequency of approximately 2.4 GHz.

7. (Original.) The method as claimed in Claim 5, in which said plurality of receiving antennas (76, 78) includes at least four receiving antennas.

8. (Original.) The method as claimed in Claim 6, adapted to mapping of human muscle, joint and bone interactions for performing clinical gait analysis of persons having neuromuscular, musculoskeletal, or neurological impairments.